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EFFECTS OF SANDFLY FEVER ON ISOMETRIC MUSCULAR STRENGTH, ENDURA--ETC(U)
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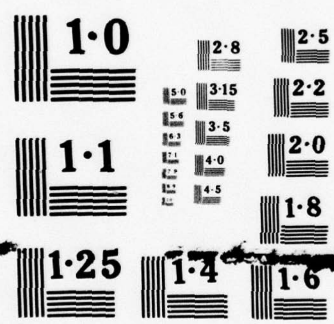

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experienced decrements in muscular strength and endurance which were significantly correlated with increases both in rectal temperature and in heart rate during the brief period of illness. Endurance was depressed to a greater extent than was strength, and the typical relative-load endurance invariance did not hold during illness. The results suggest that during early convalescence, recovery of normal muscular function was more closely related to the subject's feelings and clinical indications of well-being than to the biochemical health of the muscle as assessed indirectly by nitrogen balance and creatine excretion measurements.

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Effects of sandfly fever on isometric muscular strength, endurance, and recovery[1]

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ABSTRACT

The isometric muscular strength and endurance of two groups of ten volunteers were measured four times per day for 15 successive days. Eight subjects in one group were inoculated with sandfly fever virus on the seventh day of the 15-day experimental period and two were given sterile saline. All 10 subjects in the other group served as healthy controls. The measurements of muscle function were obtained as an incidental portion of previously reported studies concerning the effects of a mild virus illness on human work performance and responsiveness to symptomatic therapy. The virus-inoculated subjects experienced decrements in muscular strength and endurance which were significantly correlated with increases both in rectal temperature and in heart rate during the brief period of illness. Endurance was depressed to a greater extent than was strength, and the typical relative-load endurance invariance did not hold during illness. The results suggest that during early convalescence, recovery of normal muscular function was more closely related to the subject's feelings and clinical indications of well-being than to the biochemical health of the muscle as assessed indirectly by nitrogen balance and creatine excretion measurements.

muscle function; strength; endurance; sandfly fever; nitrogen metabolism; creatine

SEVERAL INVESTIGATORS have reported that the maximum duration of a sustained submaximal isometric muscular contraction is determined *in vivo* by the *relative load* imposed upon the muscle (7, 8, 14, 17). The relative load is the proportion of the maximum voluntary strength of the individual muscle group that is required in the sustained submaximal contraction. The duration of the holding time measures the endurance of the muscle group; it is a monotonically nonincreasing function of increasing relative load.

The relation between relative load and endurance has been found to be essentially identical for both large and small muscles (15, 17), for subjects with different levels of athletic competence (8), and for the same muscles when tested at different lengths (6). Endurance in these cited instances was measured by the interval of time during which a fixed relative load could be maintained, a methodological point that must be emphasized because results are less consistent where "endurance" is measured by the average maximum force that can be exerted over a fixed period of time (10, 12, 19, 20).

A great deal is known about the physical capabilities of healthy men, but very little is known about their capabilities when ill. Indeed, the literature available when these studies were conducted indicated that very little research has been published on the effects of infectious diseases on muscular strength and endurance (9, 22). Yet, it is very well established that myalgia is a common symptom during febrile illness, and that muscle protein contributes importantly in the catabolic responses to fever (2). What is not known is the extent to which these biological responses contribute to changes, presumably diminutions, in isometric muscular performance during illness.

The present study was designed to examine, with serial measurements four times daily, the isometric muscular strength and endurance (as well as recovery in strength and endurance) in the forearm musculature of young-adult male subjects before, during and after an experimentally induced, self-limited infection. This longitudinal study was conducted as an incidental portion of ongoing research investigations into the diagnostic, therapeutic, and pathophysiological effects of mild viral illness in man (1-3, 5, 16, 22). Because only a relatively small muscle group of a single limb (the preferred arm) was directly involved, the measurement procedure was judged to be safe for use with mildly ill subjects.

The procedure called for the measurement of maximum isometric strength and endurance (the latter being the duration of time for which a load of 50% of maximum strength, or a 50% relative load, could be sustained); recovery of both strength and endurance was also assessed. The major question addressed by the present study was the extent to which these muscular performances would be influenced by a condition (mild viral illness) that could be expected to alter the normal functioning of the muscles.

METHODS

The data reported herein were collected in two separate studies, one consisting of 10 subjects in the experimental group, and the other consisting of an equal number of subjects in a control group. The data of the experimental group were collected at the U. S. Army Medical Research Institute of Infectious Diseases (USAMRIID), Fort Detrick, Frederick, Maryland, incidental to a previously published investigation that included measurements of the effects of illness on sustained performance or work behavior (16) and the effects of therapy (5). Of the 10 volunteer subjects

who participated at USAMRIID, eight were inoculated with sandfly fever virus, and two served as double-blind, sham-inoculated hospitalized controls. The data of the control group were collected at the University of Louisville with equipment, measurement schedules, and procedures identical to those of the experimental group, but without infection, hospitalization, or concurrent measurement of sustained performance (11).

Subjects. The 10 subjects in the experimental group were right-handed volunteers from among Army enlisted men assigned for duty at USAMRIID. They ranged in age from 20 - 25 yr, with a median age of 22.5 yr. They were informed in detail regarding the nature and objectives of the study as well as the details of all risks and discomforts involved[3]. All their questions were answered in full and the volunteers were told that they could withdraw at any time from the study. The 10 subjects in the control group were right-handed volunteers from among the undergraduate males in the Naval ROTC program at the University of Louisville; they were paid for their participation in the study. These 10 subjects ranged in age from 18 - 20 yr, with a median age of 18.5 yr.

Apparatus. The apparatus consisted of an adjustable isometric hand-grip dynamometer, a Brush dc strain amplifier, a Brush two-channel ink-writing recorder, and visual display. The dynamometer had four active strain guages wired as a Wheatstone bridge cemented about it; this formed the input circuit of the amplifier. Pressure applied to the dynamometer created a resistive imbalance in the bridge that modulated an input signal into the amplifier. The output of the amplifier was fed into one channel of the recorder from which the signal could be read as deflections from baseline (converted by a calibration chart into pounds of force). Connected in parallel with the recorder was the visual display that consisted of a

voltmeter mounted in front of the subject's chair. The face of the voltmeter was scaled in pounds of force so that the subject could read the measured force of his exertion and thereby monitor his performance during endurance tests.

General design. The relatively simple general design was essentially identical for the experimental and control groups. The muscle system employed was that of the preferred arm and hand of right-handed subjects. Measurements of strength, endurance, and recovery were made twice at each of four different times of day on 15 successive days with each of 10 subjects in each of the two groups. The number of subjects and times of measurement were equated in experimetnal and control groups to attain the greatest possible degree of comparability, but the data of the two double-blind control subjects in the experimental group were not included in calculating the results of either group.

Procedure. The 10 subjects in each group were divided at random into two 5-man crews, A and B. The treatment of the crews differed only as to the times of day at which they were tested. Two days of practice (three sessions per subject) were given before the test measurements were begun. On each of the subsequent 15 days, each subject participated in four experimental sessions. Each session required the subject to make a series of four responses: 1) an original brief but maximum-strength squeeze on the dynamometer, 2) an original endurance measurement in which the subject held a sub-maximum load (50% of maximum) to exhaustion, 3) a secondary strength measurement, and 4) a secondary endurance measurement at the same loading (absolute force) as the first.

During each endurance test, the subject was required to monitor his output on the display meter in order to maintain it at 50% of maximum (the exact value was indicated) plus or minus 5%. There was a 1-min rest

interval after each of the four sequential tests in a session. The crews were tested at approximately 8:00 A.M. (Crew A only), 12:00 noon, 4:00 P.M., 8:00 P.M., and 12:00 midnight (Crew B only), plus or minus 30 min. That is to say, the crews in the experimental group were tested during the half-hour immediately after being relieved from a 4-h on-duty work period, and the subjects in the control group were scheduled identically, even though they did not have the 4-h periods of work as part of their testing regime. Also, since the testing required about 30 min per crew, any single subject's actual testing time on a given day might be as much as 30 min earlier or later than the listed times, and no attempt was made to test the subjects in any given order within crews. However, great care was taken to maintain constant body positioning during all measurements. Specifically, the subject was seated with his feet on the floor, arms down at the side, back straight, and eyes forward to attend to the display meter.

Metabolic studies. The subjects in the experimental group at USAMRIID were housed on a special metabolic-study ward, and fed a balanced hospital diet consisting of individually weighed servings. Complete collections of urine and stool were obtained to permit the determination of daily cumulative nitrogen balances. The urinary excretion of electrolytes, minerals, and nitrogenous compound was determined by standardized methods (3). Blood samples were obtained periodically for determinations of blood counts, growth hormone (4), aldolase (13), and creatine phophokinase (CPK) (18). Eight subjects in the experimental group were inoculated intravenously with human plasma known to contain sandfly fever virus (3, 4, 21) on the seventh day of the experimental period, and two double-blind controls (one in each crew) were inoculated similarly, but with sterile isotonic saline. Additional details concerning other aspects of the study have been published elsewhere (1, 5, 16).

Measures of Performance. Isometric muscular performance was expressed in terms of eight basic and three derived measures. The basic measures were: 1) original strength (OS) and 2) secondary strength (SS), each measured as the force in pounds of the first and second strength squeezes; 3) original endurance (OE) and 4) secondary endurance (SE), measured as the duration in seconds of the two endurance squeezes; 5) original impulse (OI) and 6) secondary impulse (SI), obtained by multiplying the force of the endurance squeezes i.e., 50% of OS, by their durations; and 7) recovery of strength (RS) and 8) recovery of endurance (RE), defined as the percentage of recovery during the interval between the original and the secondary squeezes of strength and endurance, respectively, and obtained by dividing the secondary measure (SS or SE) by the original measure (OS or OE) and multiplying the quotient by 100.

Over-all muscular performance is obviously difficult to assess with employment of all eight of the basic measures listed above, so three more general indices were derived to provide the necessary generality as well as increased statistical reliability. These indices were three mean percentages of base-line performances, one based on all eight measures, the second based on the two strength measures, and the third on the two endurance measures.

Specifically, for the over-all index, the seventh day of measurement (the day on which the experimental subjects were inoculated) was defined as the base-line day, and each of a given subject's eight test scores (one for each of the eight basic measures) was transformed into a percentage of his average score for that test on the base-line day; these percentages were then averaged across the eight measures for each subject at each time of measurement and treated as a new score, the Mean

Percentage of Base-line-Total (MPB-T). The computation of each of the other two indices was similar, but based on fewer measures: The Mean Percentage of Base-line-Strength (MPB-S) was based on only the two strength measures, and the Mean Percentage of Base-line-Endurance (MPB-E) was based on only the two endurance measures.

RESULTS

Clinical Responses. The development of infection in the eight inoculated subjects reproduced the findings of previous studies with the sandfly fever virus (3, 4, 21). Symptoms consisted chiefly of headache, myalgia, generalized malaise, and anorexia, and all subjects developed typical neutropenia. Fever developed on the second or third day after inoculation in six subjects and on the fifth day in another; one subject failed to develop fever and had only minimal symptoms and brief neutropenia. The highest rectal temperature measured in the febrile subjects ranged from 102.0 to 104.0°F. Clinical recovery was prompt in all subjects and without sequellae.

Values of the two sham-inoculated control subjects in the experimental group showed no significant change from their individual base-line values with respect to any of the clinical studies or performance measures. This served to indicate that the conditions of hospitalization and daily performance studies did not induce any systematic effect on the measurements of muscle function.

Illness-induced metabolic changes. The relations between mean daily rectal temperatures of the inoculated subjects and their nitrogen-balance and urinary-creatine data are depicted in Fig. 1. The changes indicated are typical of findings from earlier studies (3) in that the onset of illness was accompanied by anorexia which, in turn, contributed importantly to the

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occurrence of negative daily nitrogen balances. A negative mean nitrogen balance developed initially on Day 9, became maximal on Day 11, and remained negative until the end of the collection period. Relative to the pre-inoculation baseline, a cumulative loss of 56 g of body nitrogen was recorded after inoculation. As in previous studies (3), these calculations of cumulative losses were based on the assumption that the healthy adult subjects were neither retaining nor losing body nitrogen during the pre-inoculation base-line period. The measured loss of body nitrogen during Days 9 to 15 was accompained by an average total loss of 4 lb of body weight. In addition, as shown in Fig. 1, there was a five-fold average increase in urinary creatine excretion on Days 14 and 15. It is interesting to note that despite these typical manifestations of a catabolic response during sandfly fever, detectable changes in muscle enzymes were minimal. Only two patients showed a borderline rise in CPK activity in serum and only one showed a borderline increase in aldose activity.

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Hormonal changes in the inoculated subjects are shown in Fig. 2. These data indicate only a modest average increase in the excretion of urinary 17-hydroxycorticosteroid on Days 9 and 10 of the study. During these days, five of the eight inoculated subjects demonstrated urinary values that exceeded their individual preinoculation values by more than three standard deviations. Fasting plasma growth hormone values increased significantly during illness and reached their maximum concentrations on Day 11 (Fig. 2). These hormonal changes during sandfly fever were characteristic of findings in earlier studies (3, 4). Values for other components of urine such as the electrolytes, principal minerals, and nitrogenous metabolites also changed during the illness in a manner compatible with earlier data (3).

Isometric muscular performance. The deviations of original (upper

panel) and secondary strength (lower panel) from their base-line (inoculation

. 3 here day) values are shown in Fig. 3 for the virus-inoculated and control subjects on the day of inoculation and eight days following. These data indicate that the average strength of the eight inoculated subjects began decreasing on the second day after inoculation reaching a maximum deterioration on the fourth postinoculation day, whereas the strength of the controls remained near the baseline throughout the study.

. 4 here The data of Fig. 4 present the deviations of holding time from the base-line levels of original and secondary endurance. The data of the virus-inoculated subjects show that decrements in endurance were experienced one day earlier than for strength, although the maximum decrements occurred close to the same time, on the third (secondary endurance) and fourth (original endurance) days after inoculation. Essentially identical findings were also obtained in terms of the deviations of original and

. 5 here secondary impulse from baseline; these data are presented in Fig. 5. Finally, it should be noted that with each of these six measures, performance returned toward, and nearly reached, base-line values by the end of the study period, eight days after inoculation.

A somewhat different pattern of results was obtained with the two

. 6 here recovery measures shown in Fig. 6. Whereas the recovery of endurance (lower panel) was reduced by nearly 10% on postinoculation Day 4, the recovery of strength (upper panel) was only minimally (2% decrement) affected by the illness on Day 3.

. 7&8 here These results are further summarized in Fig. 7 and 8 with the three derived measures, the MPB-S (upper panel, Fig. 7), the MPB-E (lower panel, Fig. 7), and the MPB-T (Fig. 8). These data clearly indicate that maximum decrements in performance occurred three or four days after inoculation, and that performance improved toward base-line levels during the final four or five days of measurement.

A statistical comparison of the inoculated and control groups for each performance measure and index was computed with Wilcoxon Signed-ranks test. As indicated in Table 1, the results of these analyses indicate that the differences between the two groups were significant for all except the two recovery measures (strength and endurance recovery, as shown in Fig. 6). Thus, it appears that whereas the other aspects of isometric muscular performances are diminished by illness, the ability of the muscle to recover is affected minimally if at all.

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MPB-S and MPB-E performances were not significantly related prior to the onset of illness ($r = 0.49$, $df = 10$, $P > 0.10$, based on data from the day of inoculation and the two preceding days), but they were significantly correlated ($r = 0.72$, $df = 10$, $P < 0.01$) during the period of illness (the three days following inoculation) for the virus-inoculated subjects. Furthermore, during the primary period of illness (2-4 days after inoculation), isometric muscular performance in terms of MPB-S and MPB-E was significantly (and negatively) correlated with rectal temperature ($r = -0.71$ and -0.74, respectively; $df = 14$, $P > 0.01$, in each comparison). For each 1°F rise in rectal temperature there was on the average a 4.5% decrease in strength and a 8.5% decrease in endurance during these days. The correlations of strength and endurance with pulse rate were also significant, over the same period, although they were somewhat lower: -0.50 for strength (MPB-S and pulse rate) and -0.59 for endurance (MPB-E and pulse rate; $df = 14$, $P < 0.05$, in each comparison). Thus, increases in rectal temperature and pulse rate during the period of illness were associated with losses in the functional muscle capacity of those subjects ill with sandfly fever.

DISCUSSION

Although the virus-inoculated subjects showed a transient reduction in strength as the result of the experimental infection, muscular endurance was diminished to an even greater degree. In fact, normal endurance was not maintained by the subjects who were sick, even though the proportional loading technique that was used adjusted the holding forces in line with the reduced strengths. Data from previous studies using healthy, young male subjects indicate that a 50% proportional load is typically maintained for an average time of approximately 60 sec (7); a similar endurance time was evident in the preinoculation data of the present subjects. However the average endurance of the inoculated subjects was only 52 sec on the fourth postexposure day.

In healthy subjects the correlation between strength and endurance is near zero, and this correlation was not significant prior to inoculation in the present study, but was 0.74 ($P < 0.01$) for the period including postinoculation Days 1-4. Thus, the well-established relative-load endurance relation does not hold under the condition of mild virus illness.

In a recently published doctoral thesis (9), Friman described the effects on human physical fitness and skeletal muscle function of a variety of naturally occurring acute infectious diseases, chiefly of viral or mycoplasma origin. His patients were studied toward the end of their febrile period; results were compared with postconvalescence values in the same subjects and with values from a healthy control group confined to bed for the same period of time as the patients. Maximal isometric muscle strength in several muscle groups was decreased significantly as a result of illness, to values 85.4-95.0% of the subjects normal values,

while no significant changes were produced by bed rest alone. Friman's data (9) on isometric handgrip strength are in remarkable agreement with those obtained at a comparable point of recovery in the present study.

Although Friman did not measure muscle endurance, he did demonstrate a decline to 79.3% of the physical working capacity of male patients (as monitored by 150% pulse rate increases during exercise). Signs of disturbed "single fibre" neuromuscular transmission were also found in the acute phases of influenza, mumps,, and echovirus infections and muscle biopsies revealed focal deviations from normal ultrastructure as well as decreased activities of the muscle enzymes lactic dehydrogenase, glyceraldehyde-3-phosphate dehydrogenase, citrate synthetase and cytochrome-C oxidase.

The current data indicate that decrements in muscular strength and endurance were significantly correlated with increases in rectal temperature and pulse rate. It is also interesting to note that during the period of illness, changes in isometric muscular performance were paralleled by concomitant decreases in the daily levels of dietary intake and in nitrogen balance, increases in urinary 17-hydroxycorticosteroids, plasma growth hormone, and various urinary nitrogen components, but not by serum changes in muscle enzymes or urinary creatine excretion. Furthermore, following the period of peak illness, these relationships changed in significant and interesting ways. For example, each measure of muscle function included in this study indicated a return of muscle function to or toward normal by the eithth day after inoculation when the study terminated. This recovery of function was noted to be in keeping with the subjective feelings of well being in the patients and the clinical indications of their recovery from illness. Despite the return of muscle function toward

normal during postinoculation Days 4-8, the present metabolic studies suggest that, as in earlier studies with sandfly fever (3), body stores of nitrogen and body weight reached their postillness nadir, and creatine derived from muscle was lost maximally during this period of early recovery. In a subsequent study (21), quantitative measurements of daily urinary 3-methyl histidine excretion during sandfly fever showed that losses were substantially greater than base-line on postinoculation Days 2-7, with the maximal losses coming after the period of fever. The timing of the 3-methyl histidine losses is of special importance since excretory losses of this amino acid serve to indicate the _in vivo_ rate of catabolism of the contractile skeletal muscle proteins, actin and myosin (21). Thus, within the limits of the changes observed in this study, it is clear that the pattern of infection-related impairment in nitrogen metabolism and the pattern of changes in muscle function did not correspond in their temporal relationships throughout the course of the illness and early convalescence.

The present findings suggest, therefore, that the greatest impairments in isometric muscular performance correspond more directly in their timing to variables which are related to the subject's feelings and clinical indications of illness vs. well being, i.e., increased rectal temperature, anorexia with nausea, malaise, etc., that to variables associated with the internal biochemical state of an individual muscle (i.e., creatine and 3-methyl histidine excretion). This conclusion is in agreement with that of a previous study in which it was suggested that work-behavior performances during illness may be most strongly correlated with the subjective feelings of symptomatology of the person suffering the illness (5). On the other hand, no biochemical or physiological explanation is available to account for the common occurrence of myalgia

during an infectious febrile illness. Future research should attempt to determine whether changes in isometric or isotonic muscular contractilities during illness are due to central motivational variables (such as general malaise), to direct changes in the internal physicochemical state of the muscles, or to both.

FOOTNOTES

[1]Supported in part by the U.S. Army Medical Research and Development Command, Department of the Army, under Contract No. DA-49-193-MD-2567, "Behavioral Effects of Infectious Diseases." Unless otherwise stipulated in the text, all references to muscular strength, endurance, and recovery measurements are to be understood to refer specifically to <u>isometric</u> muscular contractions.

[2]At the time of the data collection, E. A. Alluisi and B. B. Morgan, Jr., were at the Performance Research Laboratory of the University of Louisville, Louisville, Kentucky, and L. S. Caldwell was primarily with the Psychology Division, U.S. Army Medical Research Laboratory, Fort Knox, Kentucky. Caldwell is currently with the Kentucky Department of Human Resources, Hazelwood Facility, Louisville, Kentucky, and Alluisi and Morgan are at the Performance Assessment Laboratory, Department of Psychology, Old Dominion University, Norfolk, Virginia.

[3]This study was governed by and conformed to the principals, policies and rules for medical volunteers as established by the U.S. Army Regulation 70-25 ("Use of Volunteers as Subjects of Research," Department of the Army, 1962) and the Code of Ethics of the World Medical Association Declaration of Helsinki. The study was conducted as part of a long-term program for the development and testing of vaccines for, and diagnosis and therapy of, acute infections. The investigations were supervised by the Commission on Epidemiological Survey of the Armed Forces Epidemiological Board. The cooperation of the National Service Organization of the Seventh-Day Adventist Church is gratefully acknowledged.

REFERENCES

1. ALLUISI, E. A., W. R. BEISEL, P. J. BARTELLONI, AND G. D. COATES. Behavioral effects of tularemia and sandfly fever in man. _J. Infect. Dis._ 128:710-717, 1973.

2. BEISEL, W. R. Effect of infection on human protein metabolism. _Fed. Proc. Fed. Am. Soc. Exp. Biol._ 25:1682-1687, 1966.

3. BEISEL, W. R., W. D. SAWYER, E. D. RYLL, AND D. CROZIER. Metabolic effects of intracellular infections in man. _Ann. Intern. Med._ 67: 744-779, 1967.

4. BEISEL, W. R., K. A. WOEBER, P. J. BARTELLONI, AND S. H. INGBAR. Growth hormone response during sandfly fever. _J. Clin. Endocrinol. Metab._ 28:1220-1223, 1968.

5. BEISEL, W. R., B. B. MORGAN, JR., P. J. BARTELLONI, G. D. COATES, F. R. DeRUBERTIS, AND E. A. ALLUISI. Symptomatic therapy in viral illness. A controlled study of effects on work performance. _J. Am. Med. Assoc._ 228:581-584, 1974.

6. CALDWELL, L. S. Relative muscle loading and endurance. _J. Eng. Psychol._ 2:155-161, 1963.

7. CALDWELL, L. S. The load-endurance relationship for a static manual response. _Hum. Factors_ 6:71-79, 1964.

8. CARLSON, B. R. Relative isometric endurance and different levels of athletic achievement. _Res. Q. Am. Assoc. Health Phys. Educ. Recreat._ 40:475-480, 1969.

9. FRIMAN, G. _Effects of Acute Infectious Disease on Human Physical Fitness and Skeletal Muscle._ Uppsala: Acta Universitatis Upsaliensis No. 245, 1976.

10. KROLL, W. Isometric fatigue curves under varied intertrial recuperation periods. Res. Q. Am. Assoc. Health Phys. Educ. Recreat. 39:106-115, 1968.

11. LYDDAN, J. M., L. S. CALDWELL, AND E. A. ALLUISI. Measurements of muscular strength, endurance, and recovery over fifteen successive days. J. Mot. Behav. 3:213-223, 1971.

12. McGLYNN, G. H. The relationship between maximum strength and endurance of individuals with different levels of strength. Res. Q. Am. Assoc. Health Phys. Educ. Recreat. 40:529-535, 1969.

13. MELTZER, H. Creatine kinase and aldolase in serum: abnormality common to acute psychoses. Science 159:1368-1370, 1968.

14. MONOD, H., AND J. SCHERRER. Capacité de travail statique d'un groupe musculaire synergique chez l'homme. C. R. Soc. Biol. Paris 151:1358-1362, 1957.

15. MONOD, H., AND J. SCHERRER. The work capacity of a synergic muscle group. Ergonomics 8:329-338, 1965.

16. MORGAN, B. B., JR., G. D. COATES, AND E. A. ALLUISI. Effects of illness (Phlebotomus fever) on sustained performance and muscular output. Hum. Factors 15:53-65, 1973.

17. ROHMERT, W. Ermittlung von Erholungspausen für statische Arbeit des Menschen. Int. Z. angew. Physiol. Einschl. Arbeitsphysiol. 18:123-164, 1960.

18. ROSALKI, S. B. An improved procedure for serum creatine phosphokinase determination. J. Lab. Clin. Med. 69:696-705, 1967.

19. START, K. B., AND J. S. GRAHAM. Relationship between the relative and absolute isometric endurance of an isolated muscle group. Res. Q. Am. Assoc. Health Phys. Educ. Recreat. 35:193-204, 1964.

20. TUTTLE, W. W., C. D. JANNEY, AND C. W. THOMPSON. Relation of maximum grip strength to grip strength endurance. _J. Appl. Physiol._ 2:663-670, 1950.

21. WANNEMACHER, JR., R. W., R. E. DINTERMAN, R. S. PEKAREK, P. J. BARTELLONI, AND W. R. BEISEL. Urinary amino acid excretion during experimentally induced sandfly fever in man. _Am. J. Clin. Nutr._ 28:110-118, 1975.

22. WARM, J. S., AND E. A. ALLUISI. Behavioral reactions to infection: review of the psychological literature. _Percept. Mot. Skills_ 24: 755-783, 1967.

TABLE 1. Summary of comparisons between inoculated and normal subjects with the use of the Wilcoxon Signed-Ranks Test (Based on data from postinoculation Days 1-8)

Measure	T Value	*P* Value
Original strength	1	<0.01
Secondary strength	0	<0.005
Original endurance	0	<0.005
Secondary endurance	0	<0.005
Original impulse	0	<0.005
Secondary impulse	0	<0.005
Strength recovery	11	>0.10
Endurance recovery	10	>0.10
Mean percentage of baseline-		
Strength	1	<0.01
Endurance	0	<0.005
Total	0	<0.005

LEGENDS FOR FIGURES

FIG. 1. Mean daily temperature, nitrogen balance, creatine excretion, and cumulative nitrogen balance for eight volunteers inoculated (I) with sandfly fever virus on Day 7. For depicting the balance data total nitrogen intakes are plotted upward from zero and losses in stool, urine, and blood are plotted downward from intake. Cumulative changes in nitrogen balance from control values have been plotted with the assumption that subjects were neither gaining or losing body nitrogen during the control period (Days 1 to 6).

FIG. 2. Mean daily temperature, urinary 17-hydroxycorticosteroids, and plasma with hormone for eight volunteers inoculated (I) with sandfly fever virus on Day 7.

FIG. 3. Deviation of average original strength (upper panel) and average secondary strength (lower panel) from their respective baselines (average of the inoculation day) for eight inoculated and 10 normal subjects during and 8 days following inoculation.

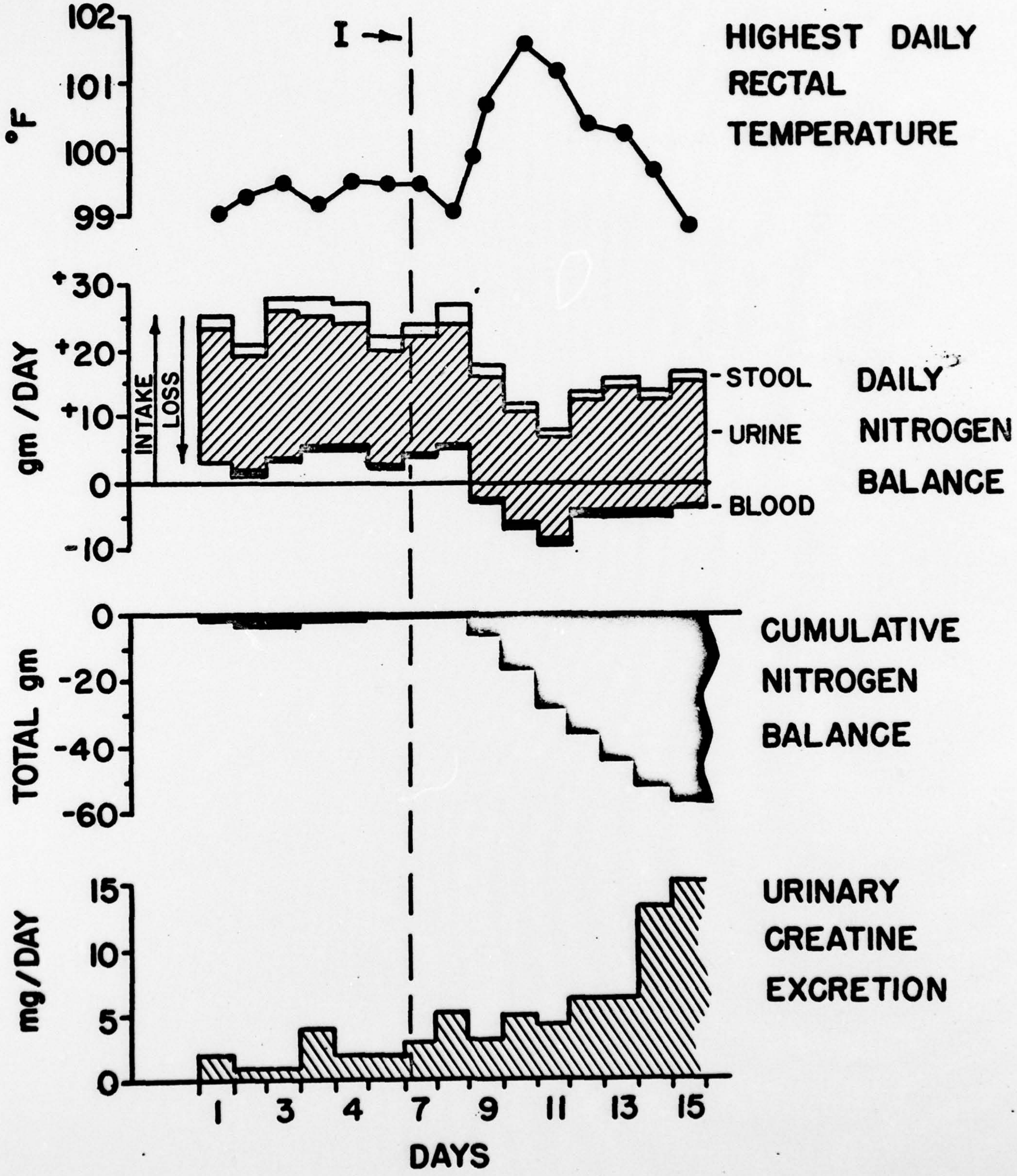
FIG. 4. Deviations of average original endurance (upper panel) and average secondary endurance (lower panel) from their respective baselines (average of the inoculation day) for inoculated and normal subjects during and 8 days following inoculation.

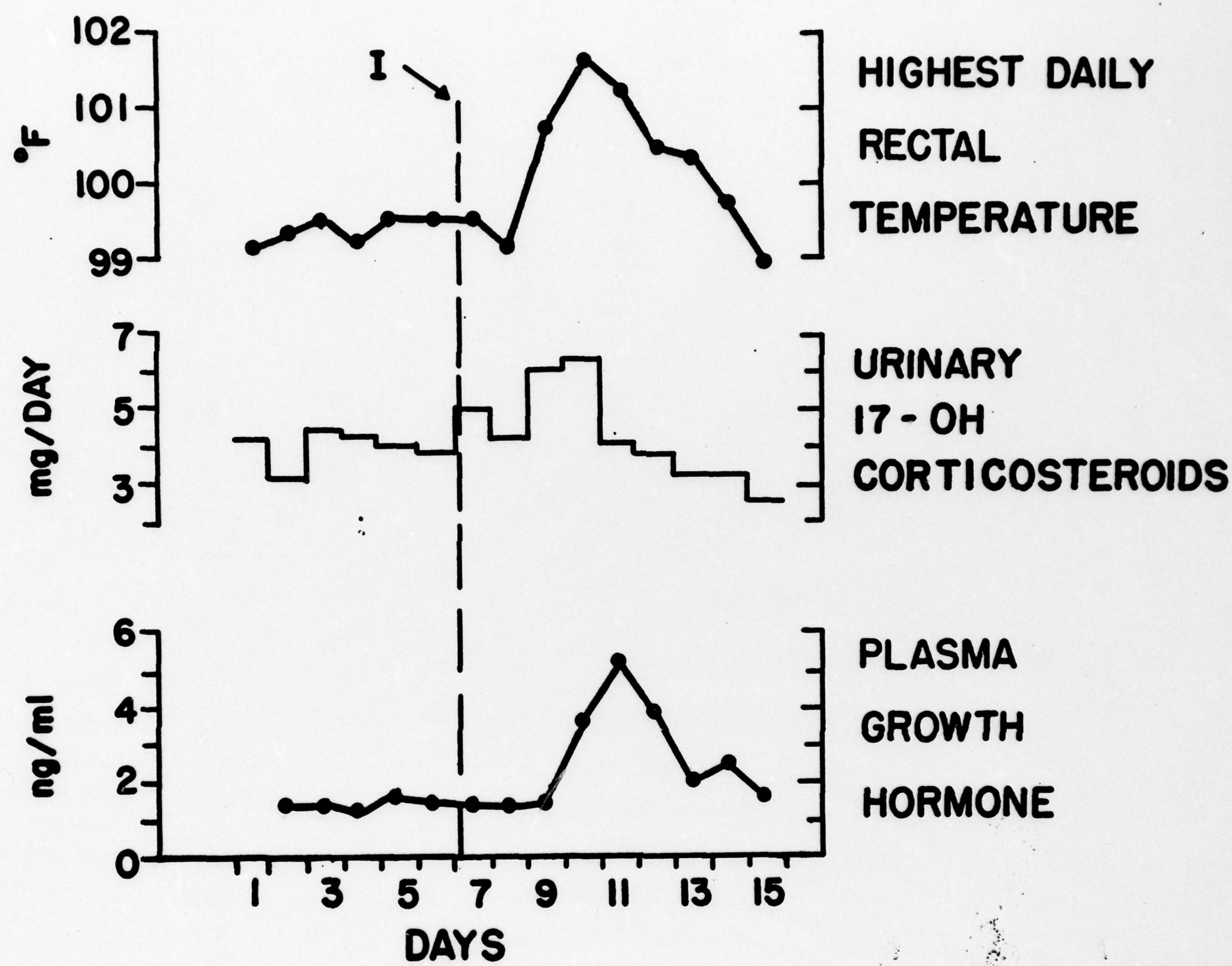
FIG. 5. Deviations of average original impulse (upper panel) and average secondary impulse (lower panel) from their respective baselines (average of the inoculation day) for inoculated and normal subjects during and 8 days following inoculation.

FIG. 6. Deviations of average strength recovery (upper panel) and average endurance recovery (lower panel) from their respective baselines (average of the inoculation day) for inoculated and normal subjects during and 8 days following inoculation.

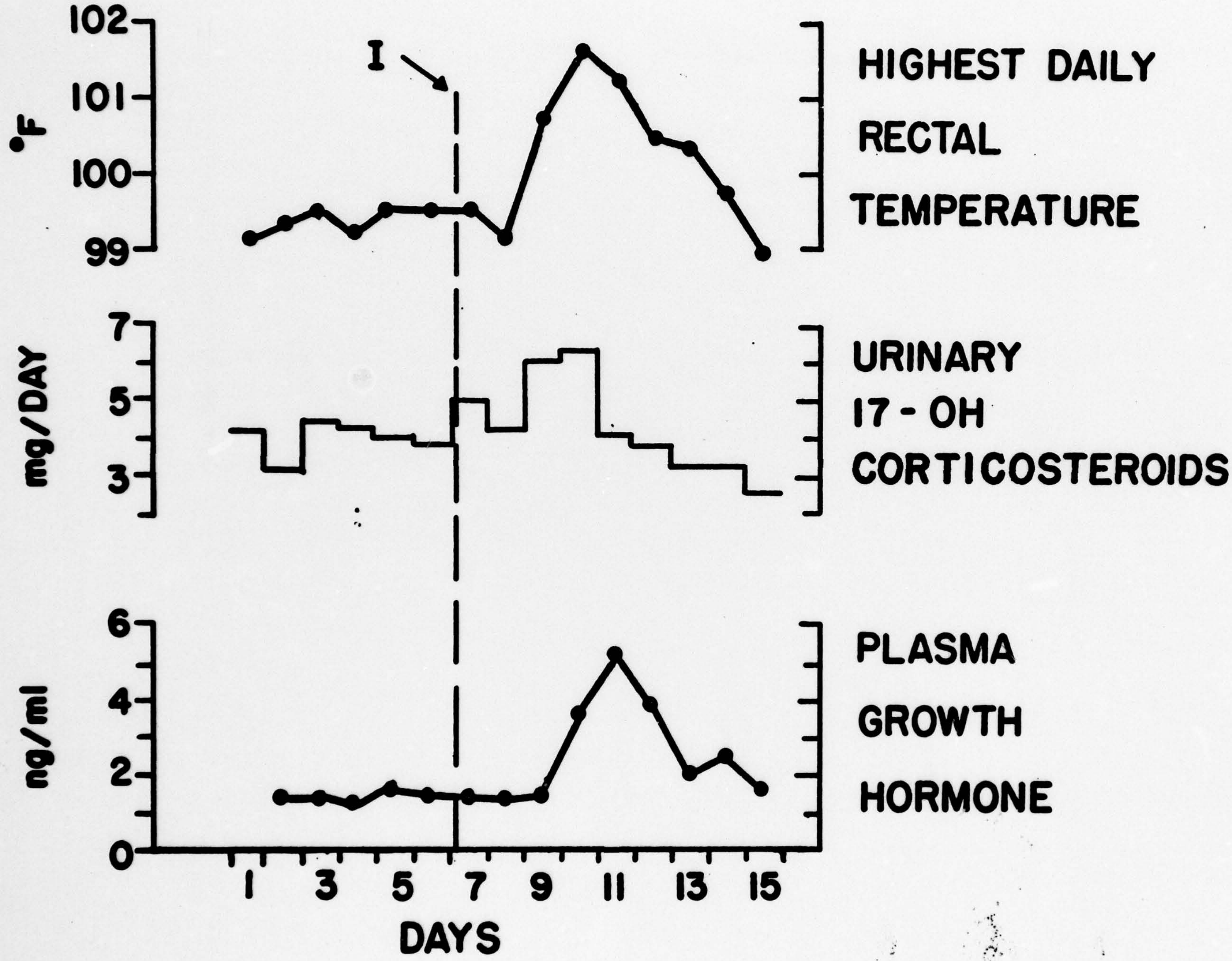
FIG. 7. Deviations of mean percentage of base-line strength (upper panel) and mean percentage of base-line endurance (lower panel) from their respective baselines (average of the inoculation day) for inoculated and normal subjects during and 8 days following inoculation.

FIG. 8. Deviations of mean percentage of base-line total from its baseline (average on the inoculation day) for inoculated and normal subjects during and 8 days following inoculation.

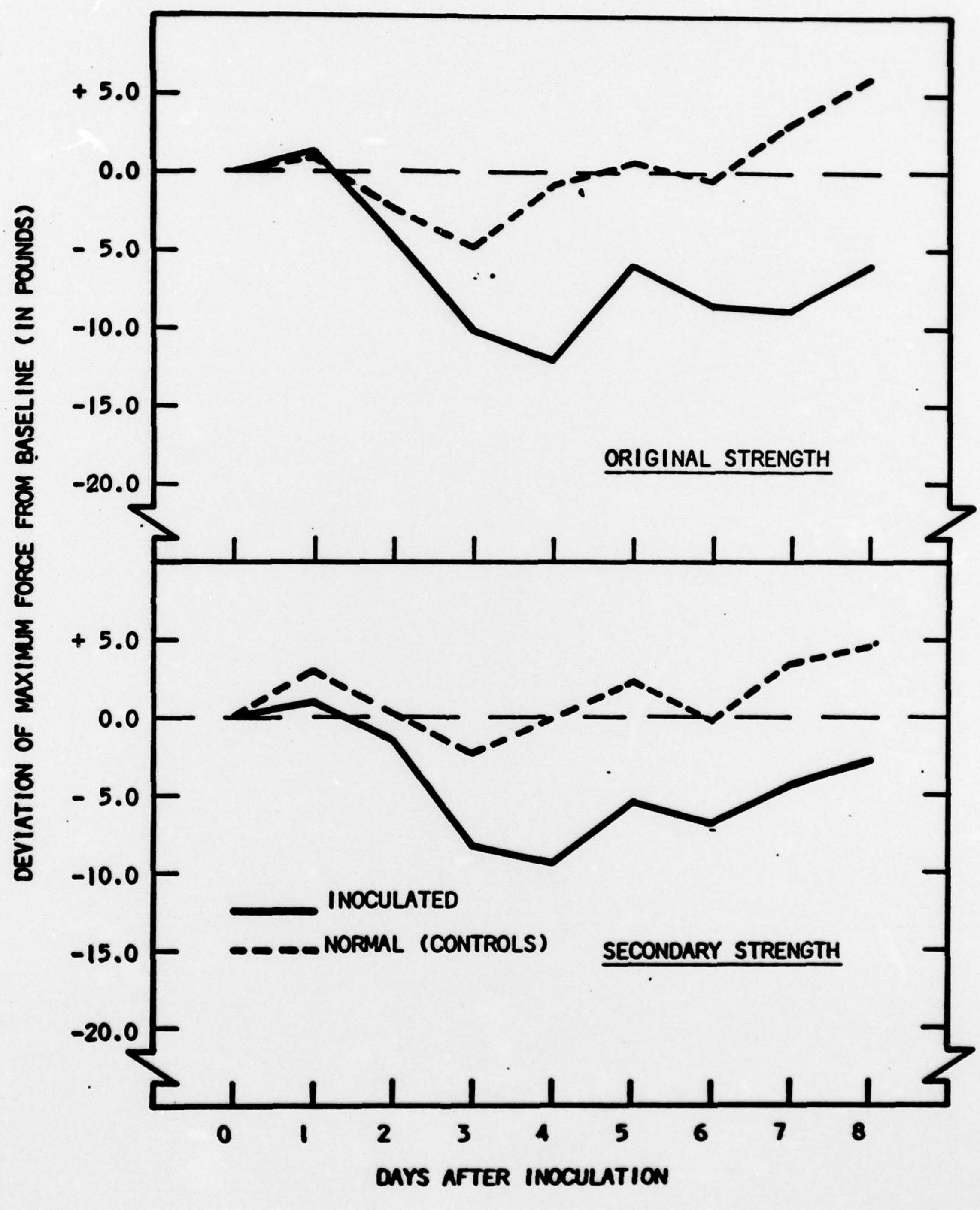

102
101
100
99
°F
I
HIGHEST DAILY
RECTAL
TEMPERATURE
+30
+20
+10
0
-10
gm /DAY
INTAKE
LOSS
STOOL
URINE
BLOOD
DAILY
NITROGEN
BALANCE
0
-20
-40
-60
TOTAL gm
CUMULATIVE
NITROGEN
BALANCE
15
10
5
0
mg/DAY
URINARY
CREATINE
EXCRETION
1
3
4
7
9
11
13
15
DAYS



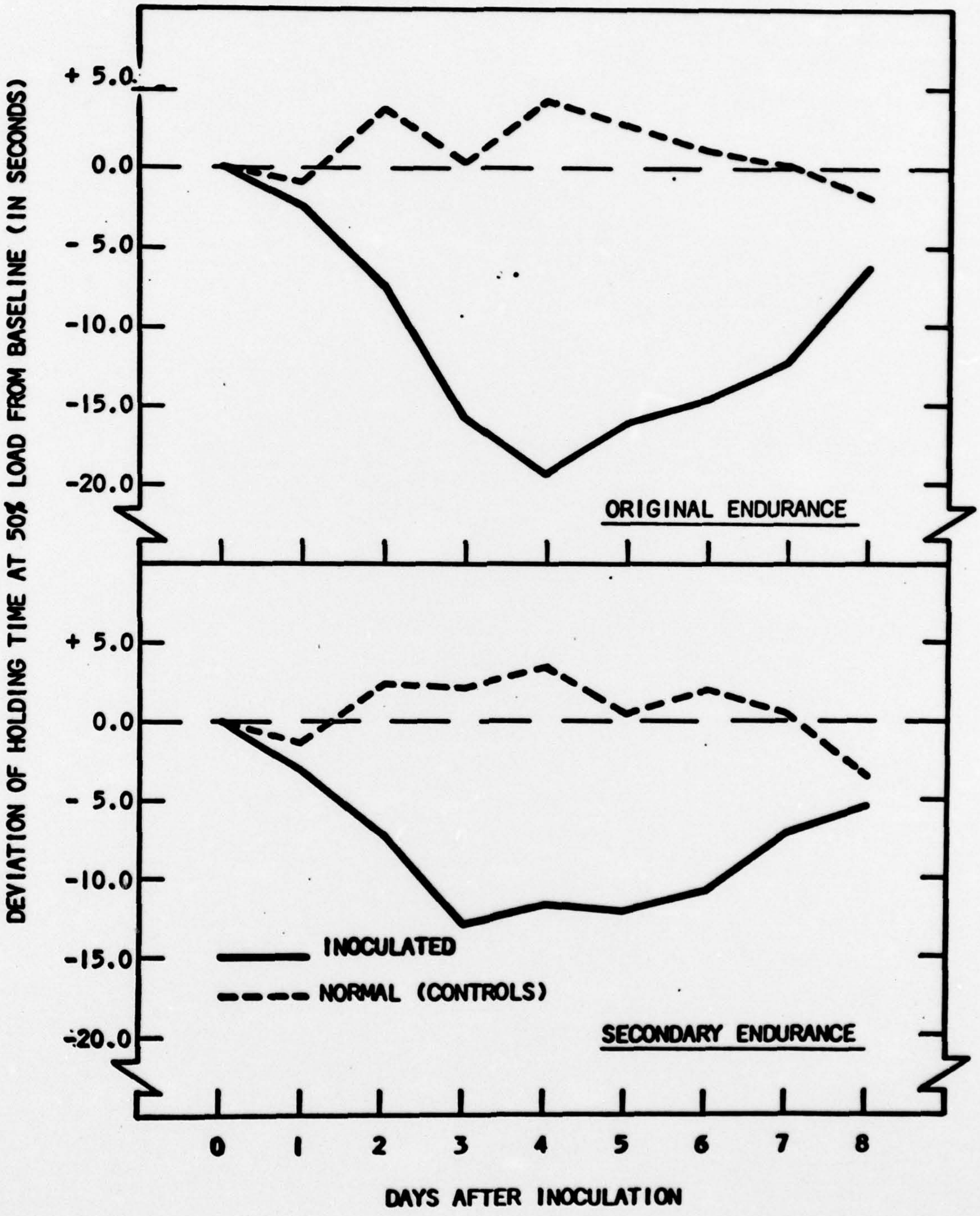
°F
102
101
100
99
I
HIGHEST DAILY
RECTAL
TEMPERATURE
mg/DAY
7
5
3
URINARY
17 - OH
CORTICOSTEROIDS
ng/ml
6
4
2
0
PLASMA
GROWTH
HORMONE
1
3
5
7
9
11
13
15
DAYS



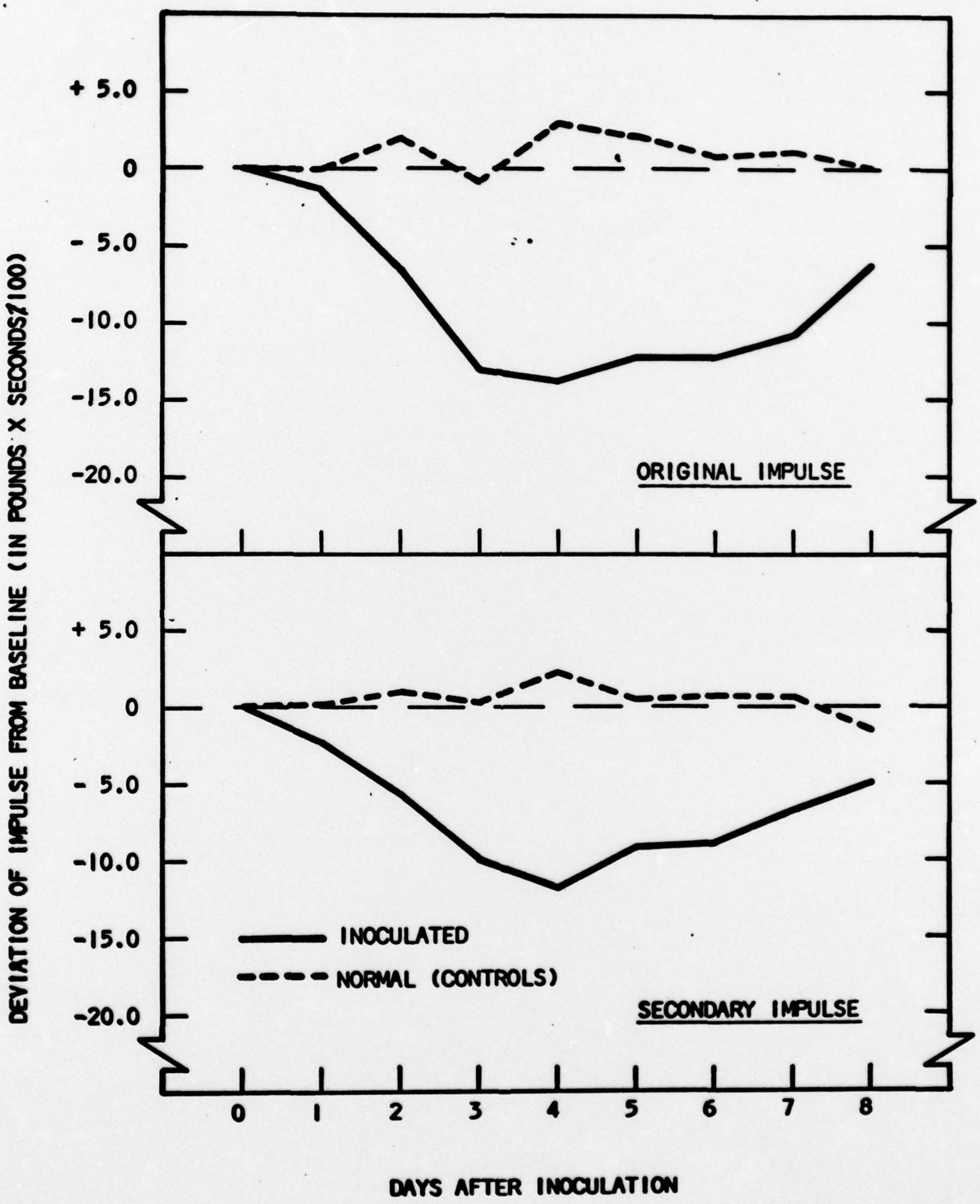
°F
102
101
100
99
I
HIGHEST DAILY
RECTAL
TEMPERATURE
mg/DAY
7
5
3
URINARY
17 - OH
CORTICOSTEROIDS
ng/ml
6
4
2
0
PLASMA
GROWTH
HORMONE
1
3
5
7
9
11
13
15
DAYS

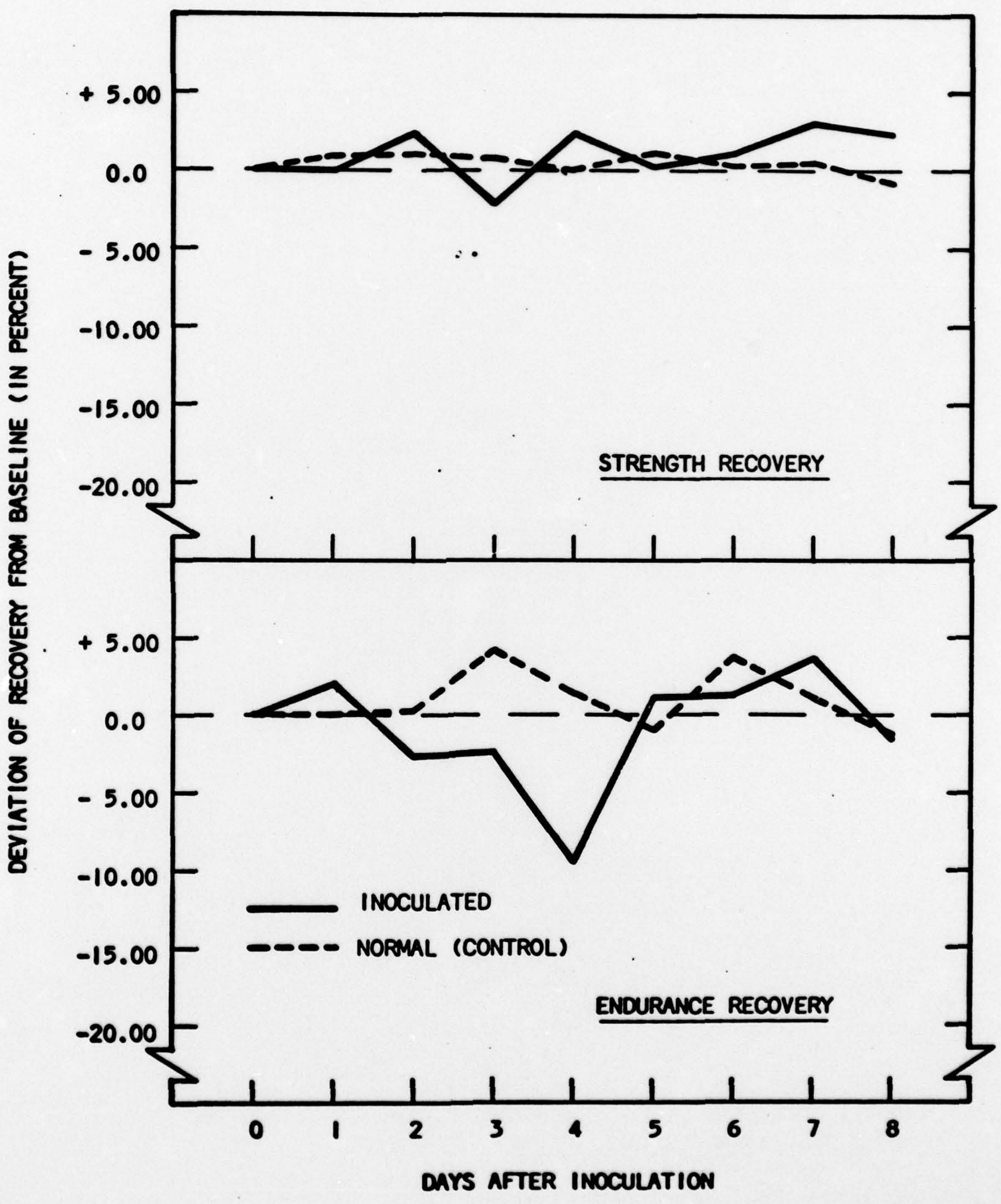


DEVIATION OF MAXIMUM FORCE FROM BASELINE (IN POUNDS)
+ 5.0
0.0
- 5.0
-10.0
-15.0
-20.0
ORIGINAL STRENGTH
+ 5.0
0.0
- 5.0
-10.0
-15.0
-20.0
INOCULATED
NORMAL (CONTROLS)
SECONDARY STRENGTH
0
1
2
3
4
5
6
7
8
DAYS AFTER INOCULATION

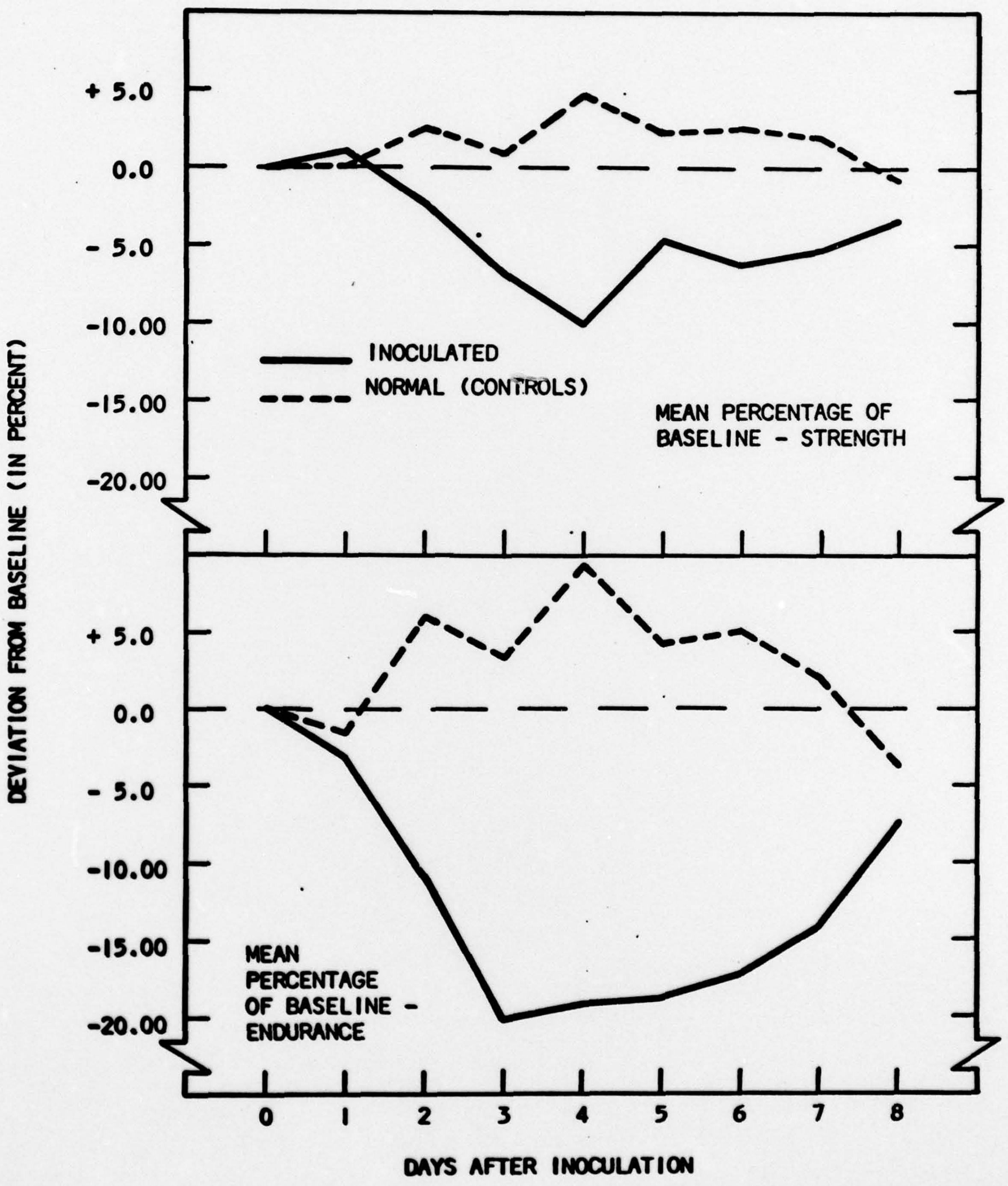


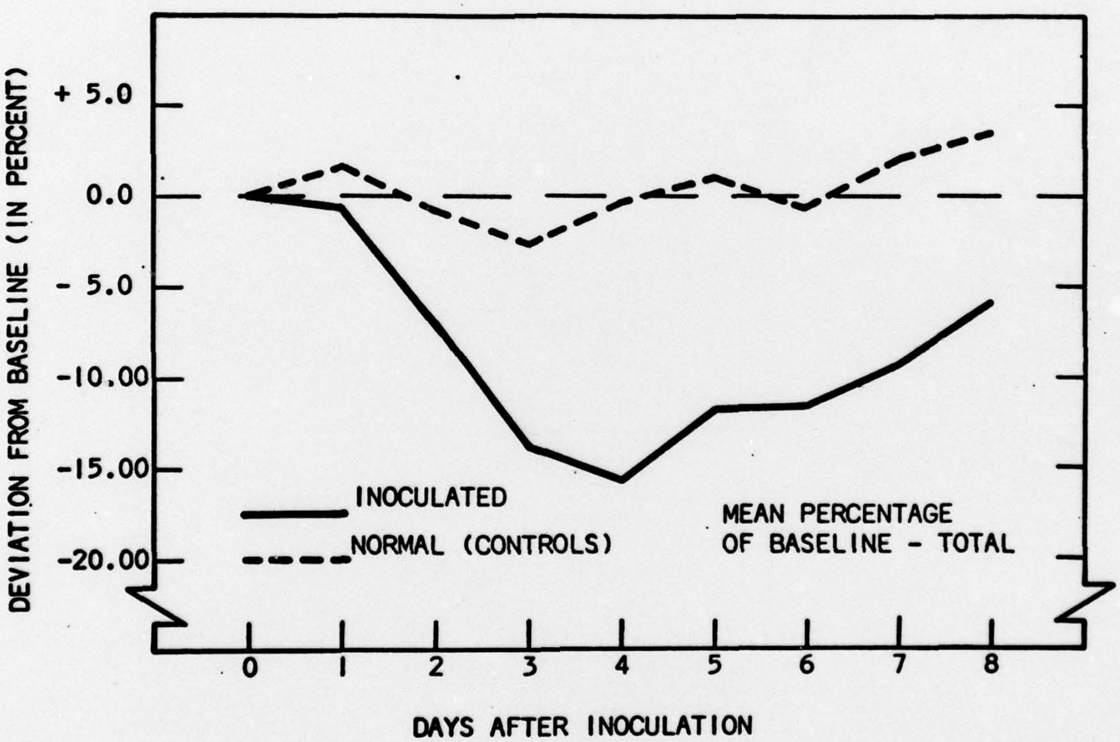
DEVIATION OF HOLDING TIME AT 50% LOAD FROM BASELINE (IN SECONDS)
+ 5.0
0.0
- 5.0
-10.0
-15.0
-20.0
ORIGINAL ENDURANCE
INOCULATED
NORMAL (CONTROLS)
SECONDARY ENDURANCE
0
1
2
3
4
5
6
7
8
DAYS AFTER INOCULATION


DEVIATION OF IMPULSE FROM BASELINE (IN POUNDS X SECONDS/100)
+ 5.0
0
- 5.0
-10.0
-15.0
-20.0
ORIGINAL IMPULSE
INOCULATED
NORMAL (CONTROLS)
SECONDARY IMPULSE
0
1
2
3
4
5
6
7
8
DAYS AFTER INOCULATION



DEVIATION OF RECOVERY FROM BASELINE (IN PERCENT)
+ 5.00
0.0
- 5.00
-10.00
-15.00
-20.00
STRENGTH RECOVERY
INOCULATED
NORMAL (CONTROL)
ENDURANCE RECOVERY
0
1
2
3
4
5
6
7
8
DAYS AFTER INOCULATION


+ 5.0
0.0
- 5.0
-10.00
-15.00
-20.00
INOCULATED
NORMAL (CONTROLS)
MEAN PERCENTAGE OF BASELINE - STRENGTH
MEAN PERCENTAGE OF BASELINE - ENDURANCE
DEVIATION FROM BASELINE (IN PERCENT)
0
1
2
3
4
5
6
7
8
DAYS AFTER INOCULATION



DEVIATION FROM BASELINE (IN PERCENT)
+ 5.0
0.0
- 5.0
-10.00
-15.00
-20.00
INOCULATED
NORMAL (CONTROLS)
MEAN PERCENTAGE
OF BASELINE - TOTAL
0
1
2
3
4
5
6
7
8
DAYS AFTER INOCULATION